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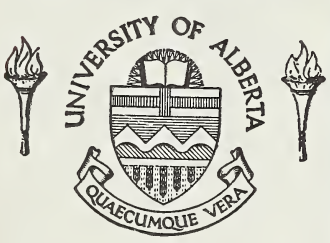

1933
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THE UNIVERSITY OF ALBERTA

A STUDY OF THE PROGNOSTIC VALUE OF A GROUP INTELLIGENCE TEST

A DISSERTATION
SUBMITTED TO THE GRADUATE FACULTY
IN CANDIDACY FOR THE DEGREE OF
MASTER OF ARTS

DEPARTMENT OF PHILOSPHY

BY
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EDMONTON, ALBERTA
MAY, 1933.

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TABLE OF CONTENTS

		Page
LIST OF TABLES		iii
Chapter		
I.	INTRODUCTION	1
II.	PURPOSE OF THE INVESTIGATION	3
III.	RELIABILITY OF THE MEASURES USED	5
	Reliability of the Otis Higher A Scale Intercorrelation of the Otis with other tests Reliability of examination marks	
IV.	METHODS, SUBJECTS, MATERIALS	19
	Methods Subjects Materials	
V.	SUMMARY OF DATA	22
VI.	QUANTITATIVE ANALYSIS OF THE DATA	36
	Correlation Prediction Conclusions	
VII.	AN EXTENSION OF THE INVESTIGATION	47
	Methods, subjects, materials Summary of data Quantitative analysis of the data	
VIII.	COMPARISONS	58
	Comparison of minor with major investigation Comparison with other studies Conclusion	
IX.	SUMMARY, CONCLUSIONS, AND CRITICISMS	69
	Summary and conclusions Criticisms and suggestions	

LIST OF TABLES

		Page
I.	IQ Scores on Otis Self-Administering Tests of Mental Ability, Higher Examination: Form A	7
II.	IQ Scores on Otis Higher Examination: Form A and on B. C. Survey Mental Tests	12
III.	Score of One Student on Nine Group Mental Tests	15
IV.	Correlation of IQ's of 57 Univ. H. S. Freshmen, 1922-23	15
V.	IQ Scores on Otis Higher Examination: Form A and Literature 4 Marks	23
VI.	IQ Scores on Otis Higher Examination: Form A and Composition 4 Marks	24
VII.	IQ Scores on Otis Higher Examination: Form A and History of English Literature 1 Marks	25
VIII.	IQ Scores on Otis Higher Examination: Form A and History 4 Marks	26
IX.	IQ Scores on Otis Higher Examination: Form A and Algebra 3 Marks	27
X.	IQ Scores on Otis Higher Examination: Form A and Geometry 3 Marks	28
XI.	IQ Scores on Otis Higher Examination: Form A and Trigonometry 1 Marks	29
XII.	IQ Scores on Otis Higher Examination: Form A and Physics 2 Marks	30
XIII.	IQ Scores on Otis Higher Examination: Form A and Chemistry 2 Marks	31
XIV.	IQ Scores on Otis Higher Examination: Form A and Biology 1 Marks	32
XV.	IQ Scores on Otis Higher Examination: Form A and Latin 3 Marks	33
XVI.	IQ Scores on Otis Higher Examination: Form A and French 3 Marks	34

LIST OF TABLES

		Page
XVII.	IQ Scores on Otis Higher Examination: Form A and German 3 Marks	35
XVIII.	Summary of Correlations Based on Material in Tables V--XVII.	41
XIX.	Showing the Forecasting Efficiency for Correlation Coefficients--IQ vs Marks	44
XX.	Practical Interpretation of the Per Cent of Forecasting Efficiency for Different Values of r	45
XXI.	Estimated Scores for a Grade XII Student, IQ = 110, Departmental Examinations--1932	48
XXII.	Algebra 1 and Algebra 2 Marks Departmental Examinations	53
XXIII.	Algebra 3 and Algebra 2 Marks Departmental Examinations	54
XXIV.	Algebra 3 and Algebra 1 Marks Departmental Examinations	55
XXV.	Summary of Correlations Based on Material in Tables XXII--XXIV	57
XXVI.	Showing the Forecasting Efficiency for Correlation Coefficients--Marks vs Marks	59
XXVII.	IQ Scores on Otis Higher Examination: Form A and Marks (Algebra 3)	64

CHAPTER I

INTRODUCTION

A leading book on measurement says: "Science holds prediction as its most important aim and prognosis is the ultimate aim of endeavor in the scientific study of education."[1] Any prognosis, that is worthy of the name, must be built upon measures of individual ability and achievement, not upon personal opinion. How then shall we predict high school achievement? For the practical school man the choice of the best basis of prediction narrows down to two possibilities, 'general' intelligence tests and previous academic record. Which basis is better? Unfortunately there is no general agreement as to the answer.

Briefly stated, a satisfactory prediction meets three conditions, namely, validity, reliability and usability. The most important of these is validity, for by validity is meant truthfulness. Insofar as the prediction is realized, it is considered valid. By reliability is meant consistency of prediction. The validity of a prediction is limited by its reliability, although high reliability in itself does not guarantee high validity. By usability is meant practicality. Are the predictions capable of being arrived at and used with sufficient ease to make them practical, or do they call for too great an expenditure of time and energy for the returns they yield? The extent to which they meet this test determines

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1. Symonds, P.M., "Measurement in Secondary Education", (1929), pp. 363.

their usability.

When measured by these three standards or criteria how do the bases of prediction, named above, compare in merit? As the previous records of the pupils are always available it is clear that such records excel the other basis in usability but the relative merits of the two in validity and reliability present a more troublesome problem as the literature of both is quite extensive.

In this investigation it was impossible to deal with the whole problem as outlined above. Definite limits had to be set.

CHAPTER II

PURPOSE OF THE INVESTIGATION

It is the purpose of this investigation to present data concerning the value of the Otis Self-Administering Tests of Mental Ability, Higher Examination: Form A in predicting success or failure in the later years of high school. For the purpose of this investigation, the measure of a pupil's success in a subject was determined by the marks obtained by that student on a departmental examination in the subject. School success is usually measured by means of ordinary marks because they can be objectively judged and recorded, and, barring accidents, they represent differences in the quality of school work. Several investigators[1] have made studies of the value of scores yielded by different intelligence tests in predicting high school or college success. Usually the investigator gives his subjects several tests and is thus able to compare the predictive values of the various tests used. It was necessary to limit the present investigation to scores obtained on a single intelligence test.

A minor purpose of the investigation is to present data concerning the reliability of the measures used, namely, intelligence test scores as yielded by the Otis S-A Tests

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1. (a) Brown, A.M., J. Ed. Psych. 1924, (15), pp. 448-462, "A Study of the Predictive Value of Certain Kinds of Scores in Intelligence Tests."
   (b) Tozer, George E., J. Ed. Res. 1930, (22), pp. 399-402, "A Statistical Prediction of High-School Success for Purposes of Educational Guidance."

of Mental Ability: Higher A and marks obtained on departmental examinations.

A second minor purpose of the investigation is to present data concerning the value of marks obtained on departmental examinations in the preceding units of a subject in predicting success or failure in the final unit of that subject. This latter data is given for only one subject (Algebra) and is for the purpose of comparison and check.

Data on the reliability of IQ scores and marks will be presented first, the main thesis of the study will next be presented in some detail, and, finally, the data concerning the relative predictive value of academic record vs IQ scores will be presented.

CHAPTER III

RELIABILITY OF THE MEASURES USED

Before proceeding with the main thesis of this report--to find the value of the IQ scores (obtained by Otis S-A Tests of Mental Ability: Higher A) in predicting high school success--it seemed desirable to present data on the reliability of the measures used throughout the investigation, as follows:

Reliability of the Otis Higher A Scale

(a) Reliability given by Otis.-By reliability is meant the degree to which the scores of the test measure whatever the test measures. Reliability is best determined by means of the correlation between different forms of the same test. Otis[1] gives the coefficients of correlation between Forms A and B of the Otis Self-Administering Tests of Mental Ability as follows:

Higher Examination, Grades 7 to 12:

Group I, Form A first, 128 cases, $r = .917 \pm .009$)
Group II, Form B first, 125 cases, $r = .925 \pm .009$) Aver. .921

The values of the probable error of a score determined from these groups were 2.56 and 2.68 points for the Higher Examination. This means that the probable error of an IQ is about 2½ points.

(b) Reliability found by repeating the test.-In this study reliability of the Otis Higher A Test was measured by

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1. "Manual of Directions and Key (Revised) For Intermediate and Higher Examinations Otis Self-Administering Tests of Mental Ability." p. 12.

finding the coefficient of correlation of the measures obtained by repeating the same test. This method was used because only Form A of the Otis Higher Examination had been given the subjects under consideration.

The measures used in this test of reliability were obtained in the Garneau and Victoria High Schools. Ninety-seven pupils in Garneau High School grades X, XI and XII and one hundred and forty-one in Victoria High School grades IX, X, XI and XII took the Otis Higher A test ($Otis_1$) in January 1932, and the same test ($Otis_2$) in May 1932. This made a total of 238 pupils. The data obtained from this source are given in Table I:

TABLE I

IQ SCORES ON OTIS SELF-ADMINISTERING TESTS OF MENTAL ABILITY
HIGHER EXAMINATION: FORM A

OTIS (HIGHER A) SCORES — May, 1932

	OTIS (HIGHER A) SCORES																	Jan. 1932
	80	83	86	89	92	95	98	101	104	107	110	113	116	119	122	125	128	
132														1				1
129												1						1
126										1			1	1	3	11	1	18
123								1			6	2	2	6	4			21
120										2	3	1	3	4	3		1	17
117						1		2	2	8	5	4	5	3	1			31
114			1					1	1	5	1	6	4					19
111							1	3	3	1	15	3						26
108				1	3	2	7	3	2	8	6	1		1				34
105					3	2	4	5	10	5	2		1					32
102					2	2	3	2	1	1	1							12
99						1	2	2	2									7
96		1		1	1	2	1		1		1							8
93				1	2			1										4
90			2															2
87	1	2	1															4
84					1													1
	1	3	4	3	12	10	18	20	22	31	40	18	16	16	11	11	2	238

Table I is an excerpt from a Ruch and Stoddard correlation sheet. The Pearson r representing the degree of relationship between the two paired series is positive 0.79 ± 0.02. The two series of measures may be summarized as follows: The range in IQ score values on the $Otis_1$ Test (January 1932) was from 81 to 129 with a mean score of 108.85 and a standard deviation of 9.87; on the $Otis_2$ Test (May 1932) from 87 to 128 with a mean score of 112.98 and a standard deviation of 9.39.

One hundred and forty-six pupils had IQ scores higher on the second test than on the first. The score range of these increased scores extended from 1 to 30 points IQ with a median of 7.17 points IQ higher on the $Otis_2$ Test than on $Otis_1$, and a quartile deviation of 3.67 points IQ. Forty pupils had IQ scores lower on the second test than on the first. The score range of these decreased scores extended from 1 to 12 points IQ with a median of 3.30 points IQ lower on the $Otis_2$ Test than on $Otis_1$, and a quartile deviation of 1.81 points IQ. Fifty-two pupils in the group of 238 had the same IQ on both the $Otis_1$ and the $Otis_2$ Tests. In this investigation the trend in IQ shift is upward on the re-test.

On the reliability of repeated tests Terman says, "In general, the same tests give consistent results. Something depends, however, on the age and intelligence of the subject and on the time interval between the examinations."[1] He

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1. Terman, "The Measurement of Intelligence," p. 113.

found that, on the whole, older and superior children profited more from the experience of a retest than younger and backward children did. He concluded, "While it would probably be desirable to have one or more additional scales for testing the same children at very brief intervals, the same scale may be used for repeated tests at intervals of a year or more with little danger of serious inaccuracy."[1]

Truman L. Kelley attaches very little importance to the reliability coefficient found by giving the same test twice at short intervals.[2] He says, "The correlation coefficient so found is very misleading and, in general, higher numerically than the correct reliability coefficient. This is because there is a correlation between errors. The mental operation in the second test is not at all of the same sort as the operation in the first test. On the second the main feature is memory or a reinstating of what took place on the first, while on the first the question was a typical problem situation not involving these memory elements at all."

Notwithstanding criticism of the only method of finding the reliability coefficient which could be used in this study, the writer decided to include in her report the results found by correlating two sets of measures obtained by the re-test method. It was thought that such results could be relied upon to a degree since at the time of taking the first test no pupil thought that he would ever again be asked to take an intelligence test. Under such conditions, it does not seem possible that the second test would merely be a reinstating of what took place on the first. If the tests had been given

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1. Terman, "The Measurement of Intelligence," p.114.
2. Kelley, "Interpretation of Educational Measurements", pp. 39-40.

at least one year apart, instead of four months, one could be reasonably certain that the 'carry over' to the second test was negligible.

At this point it is interesting to look into a study by C. L. Cushman.[1] A summary of results is as follows:

	Tests Compared			
	Binet & Binet	Binet & Otis A	Otis A & Otis A	First & Second
No. Cases	144	64	52	260
Aver. diff. IQ (1st & 2nd) (disregard sign)	7.8	9.5	7.2	8.0
r (between 1st & 2nd)	.74±.025	.72±.04	.74±.03	.74±.019

The only part of the summary which concerns us here is the $Otis_1$ vs $Otis_2$. In our study, N = 238, Aver. diff. IQ (disregarding sign) is 5.27, and r is 0.79 ± 0.02.

Intercorrelation of the Otis with other Tests.

(a) Intercorrelation with the B.C. Survey.-The coefficient of reliability shows the accuracy of the measurement but it does not tell us if what is measured is really intelligence. Some idea as to whether or not intelligence is really measured by intelligence tests, that is, if all the tests measure the same things, is obtained from the intercorrelations of various tests. As in finding the reliability coefficient, so in finding the intercorrelations with other tests, the supply of available material was limited. Otis Higher A scores were correlated with B.C. Survey Test scores. The measures used in this part of the

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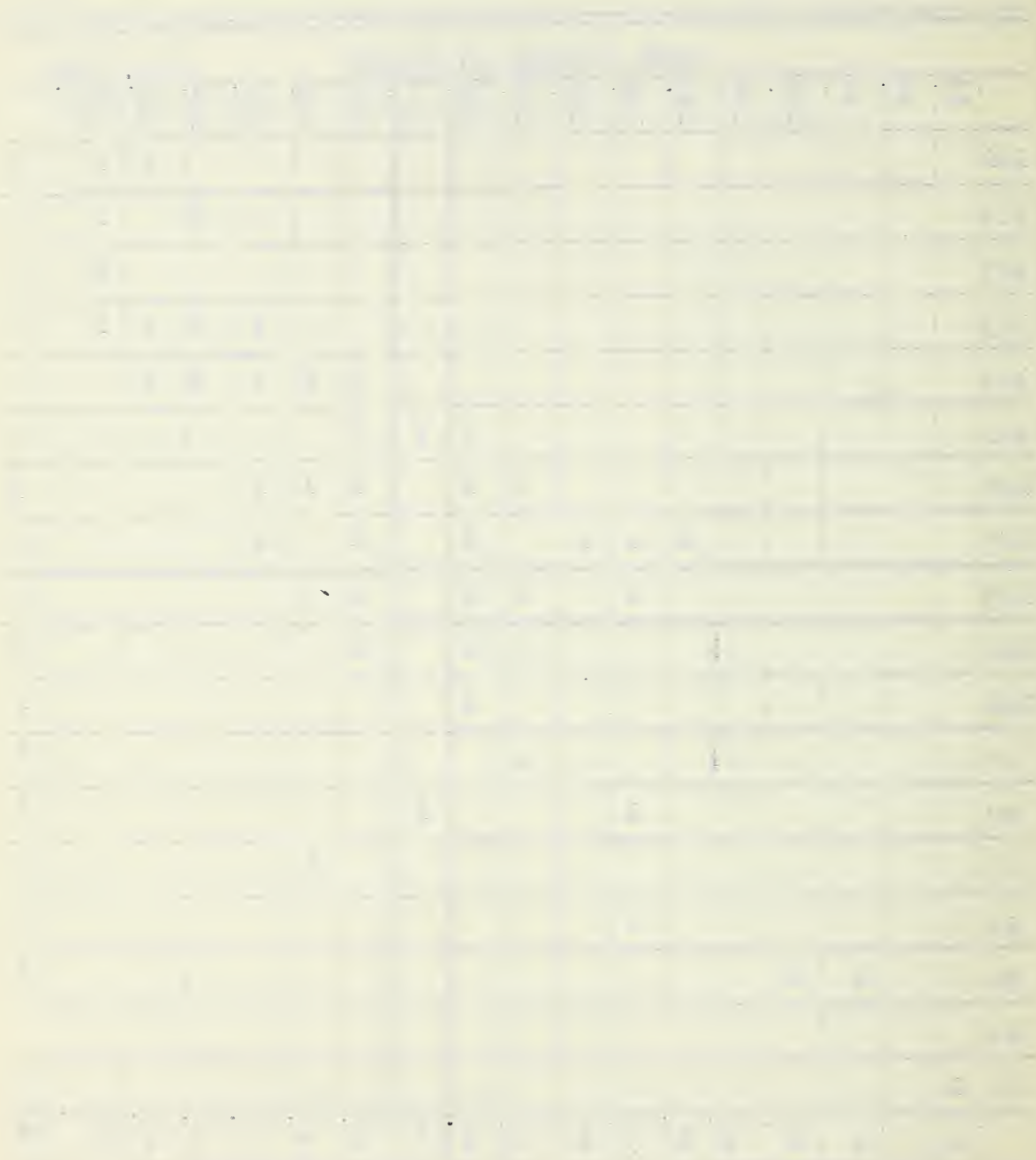
1. Cushman, C.L., J. App. Psych., Dec. 1927, "Reliability of Mental Tests in Oklahoma City."

investigation were obtained in the Garneau High School, January 1932. Sixty-two pupils in Grades X and XII took both Otis and B. C. Survey tests. The data obtained from this source are given in Table II:

TABLE II

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A AND ON B.C. SURVEY MENTAL TESTS

	OTIS (HIGHER A) SCORES																	Jan. 1932
	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	
121																2	1	3
119															2		1	3
117																	2	2
115														3	2	1	1	7
113												1	1	1	2	2		7
111										1	1	2						4
109									1	1		1	1	1				5
107						1	1	1		2		2		1				8
105							2		1	1		1	1					6
103					1				3	1		1						6
101										1								1
99					1				1									2
97							1				1							2
95													1					1
93							1											1
91			1	2														3
89																		
87	1																	1
	1		1	2	2	1	5	1	6	7	2	8	4	6	6	5	5	62



The Pearson r representing the degree of relationship between the two paired series is positive 0.84 ± 0.03. The two series of measures may be summarized as follows: The range in IQ score values on the Otis test was from 94 to 127 with a mean score of 115.71 and a standard deviation of 7.82; on the B.C. test from 88 to 122, with a mean score of 108.81 and a standard deviation of 7.98.

One pupil had an IQ score higher by three points on the B.C. test than on the Otis. Fifty-seven pupils had IQ scores lower on the B.C. than on the Otis. The score range of these decreased scores varied from 1 to 22 points IQ, with a median of 7.88 points IQ lower on the B.C. than on the Otis, and a quartile deviation of 2.62 points IQ. Only four pupils in the group of 62 made exactly the same IQ on both the Otis and B. C. tests. In this investigation the trend in IQ shift is downward on the B.C. test. No information could be obtained on the reliability of the B.C. Test. It is a comparatively recent one.

(b) Intercorrelation with other tests reported.-Of the intercorrelating of intelligence tests there seems to be no end. It appears that the Otis Higher Examination: Form A has been correlated against every other well-known test, both group and individual. Excerpts from two or three of these studies, as reported, will be given here: (1) J.A. Clement reports the intercorrelations of the Army, Otis, Thurstone, Pressey and Indiana group tests as follows:[1]

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1. Clement, J.A., "Educ. Admin. & Super.", 1920, (6), pp.433-444.

Army	Thurstone	r=.60	N = 49
Army	Otis	.57	"
Army	Pressey	.36	"
Army	Indiana	.36	"
Otis	Thurstone	.46	"
Otis	Pressey	.44	"
Thurstone	Pressey	.25	"
Thurstone	Indiana	.25	"
Pressey	Indiana	.22	"

Denton Geyer compares the following coefficients of correlation between two forms of the same test:

Otis A-B, r = .79, N = 306 (Snarr)
Otis A-B, r = .83 ave., N = 50 schoolrooms (Colvin)

with the correlations found in Clement's report. He concludes that the wide variation leads one to doubt somewhat that the different tests--Army, Otis, Thurstone, Pressey and Indiana--are really measuring the same elements in the pupil's endowment.[1]

Another study (2) is reported by W. S. Miller. He gave ten (10) intelligence tests to fifty-seven (57) freshmen entering the Univ. of Minn. High School in 1922.[2] From the data so obtained he made a study of the variation and significance of IQ's from group intelligence tests. The results of his investigation are given in tabular form as follows:

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1. Geyer, Denton, J. Ed. Psych., 1922, (13) p. 43, ff.
2. Miller, W.S., J. Ed. Psych., 1924, (15), p. 359, "Variation and Significance of IQ's from Group Tests."

TABLE III

SCORE OF ONE STUDENT ON NINE GROUP MENTAL TESTS

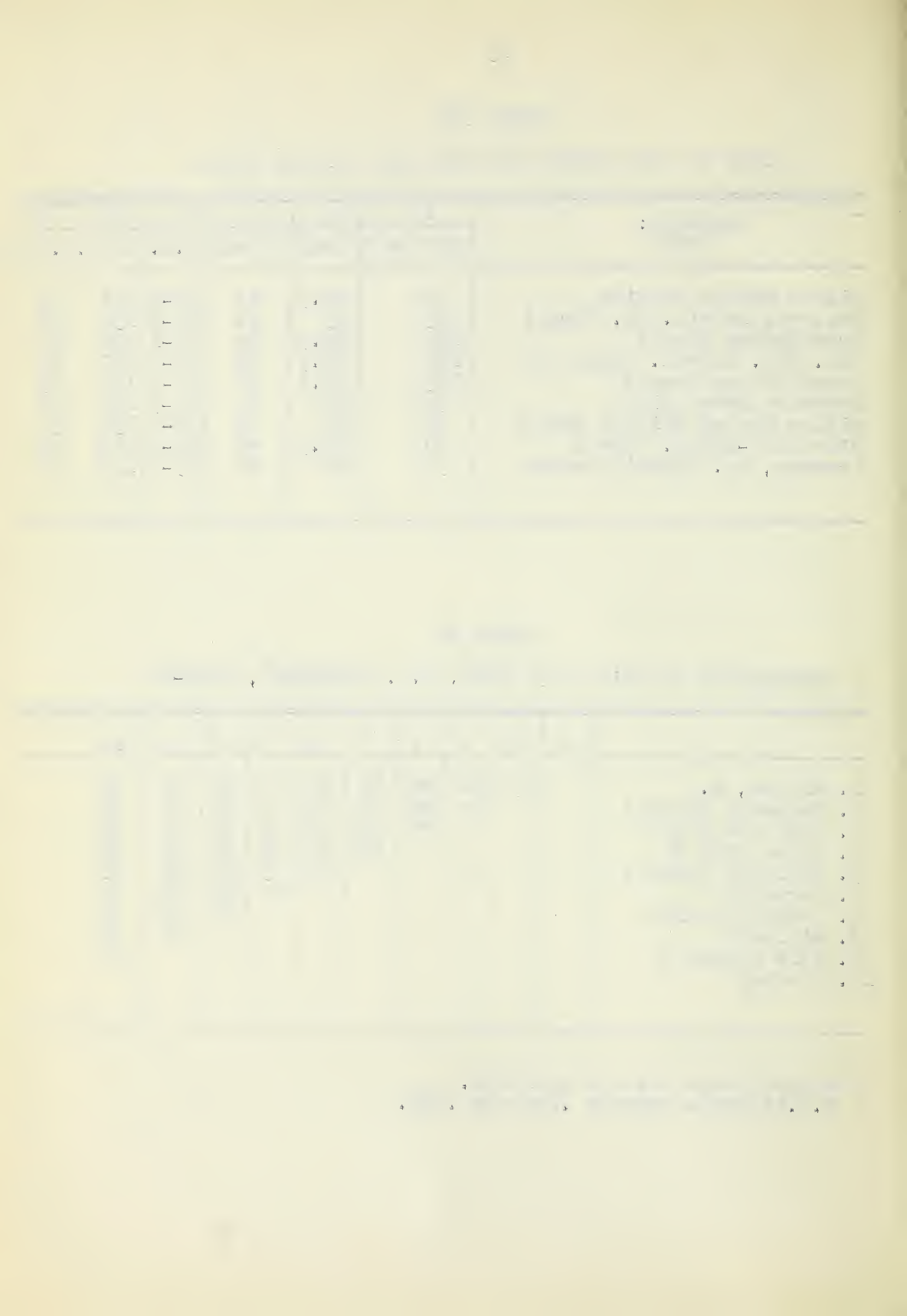
RESULTS: TESTS	1 Raw Score	2 Rank	3 % Rank	4 M.A.	5 IQ	6 S.D.Score
Miller Mental Ability	73	21.5	62	18-10	141	54
Haggerty Intell. Ex. Form A	145	15	74	20-0	150	62
Army Alphas Form 8	121	20.5	64	17-1	128	53
Ill. Gen. Intell. Scale F 1	121	26.5	54	17-7	132	51
Terman Group Form A	145	15.5	73	16-5	123	55
Dearborn Group II C	57	22	61	16-5	123	54
Miller Mental Ability Form B	82	12	79	20-4	152	57
Otis Self-Admin. Form A	47	29.5	48	15-9	118	51
Pressey, Sr. Classification	53	33	42	15-10	119	50

TABLE IV

CORRELATION OF IQ'S OF 57 UNIV. H.S. FRESHMEN#, 1922-23

	1	2	3	4	5	6	7	8	9	10
1. Miller, A.		75	70	89	82	87	74	90	86	82
2. Haggerty Delta 2			70	77	76	79	70	77	76	82
3. Stanford Binet				77	77	74	70	76	76	80
4. Alpha Form 8					90	90	77	94	83	89
5. Illinois Scale 1						83	75	83	82	85
6. Terman A							77	91	86	89
7. Dearborn II C								78	80	75
8. Miller B									87	85
9. Otis Higher A										84
10. Pressey										

Correlations are all positive.
P.E.'s range between .009 and .086.



From Tables III and IV it may be seen that although the spread in IQ is considerable (1-34) the intercorrelation between any two of the tests is never less than 70. It is a well-established fact that IQ's yielded by some tests are consistently lower than those yielded by others. The student , under consideration, was given a lower M.A. on the Otis than on any other. The highest possible score for a 12-year-old on the Otis Higher A Examination is 75 and the Binet Mental Age equivalent of this score is 19-6. The corresponding IQ is 152. Assuming that the pupil's performance on all the tests was equally good, we may conclude that relatively speaking the IQ yielded by the Otis Higher A is low, or, at most, average. Of course, the fact that a test measures consistently low or consistently high does not alter the value of the coefficient of intercorrelation with another test. The average of the intercorrelations for four of the tests is higher and for four lower than for the Otis.

The Reliability of Examination Marks

Marks are the universal measures of school work. Numerous and momentous problems in the operation of a school depend upon them. If we consider marks from a scientific viewpoint as a measuring scale, three fundamental questions arise: (1) How fine a scale of units may be used satisfactorily? (2) How reliable are the ratings made on the particular scale adopted? (3) How shall the marks be

distributed? Only the second problem need concern us in this study. Our problem is, How reliable are departmental examination marks?

Dearborn, Finkelstein, and others have conducted investigations in order to show precisely the accuracy, or rather the inaccuracy, of marks. They each found that the marks assigned to the same paper by different teachers varied enormously and that the variability or unreliability of marks was as great in one subject as in another.[1] In these experiments no attempt was made to control conditions under which the papers were marked. In each case the examiner was given a question paper and an answer paper and asked to evaluate the latter.

In general, marks are unreliable because they suffer not only by a want of any common standard but also by a lack of agreement as to the basis of marking.

With reference to the lack of a common standard of marking examination papers, we may say that although Max Meyer and others have developed plans for overcoming this difficulty in school or university marks, no such plan has been devised for doing away with the variability of standards of teachers marking departmental examination papers. We may say then, that, roughly speaking, there are as many standards of marking as there are examiners and, perhaps, as many as there are papers marked. One writer on Educational Measurements assures us that an examiner sets a new standard every time

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1. Starch, D., "Educational Measurements", Ch. I.

he marks a paper. If this be true, our measures are highly unreliable on this score.

With reference to the basis of marking,in our case something has been done to secure agreement. Groups of examiners who had made a study of the examination questions met, discussed, and agreed upon a basis of marking before marking any papers, with the exception of three or four evaluated by each examiner for demonstration purposes. In case of unforeseen difficulties, requiring new rulings, the chairman of the group was the final court of appeal. He also re-read papers close to the dividing line between passing and failing, and a small percentage of papers marked by each member of his group. On the whole, it would seem that marks on departmental examinations are quite reliable, as marks go.

CHAPTER IV

METHODS, SUBJECTS, MATERIALS

The main thesis of this investigation was based upon data obtained from files and records in the Edmonton Public School Board Offices. Twenty-four large sheets were required for the complete record.

Methods

For each student the following items were recorded: the number assigned to him by the investigator, name, IQ score, and the various marks obtained by him on departmental examinations, June 1932. Although only Grade XII marks were used in this investigation, it was thought that the other marks might be used in a subsequent investigation, hence they were included.

With this arrangement it was a simple matter to read off the IQ score and the mark obtained on any subject for any pupil. For each of the thirteen (13) Grade XII examination subjects a list was made of the IQ's and marks obtained by all pupils taking departmental examinations in that subject. The next step was to find the coefficients of correlation between each of the paired series: IQ scores vs Marks (Lit. 4); IQ scores vs Marks (Comp.4); etc. Ruch and Stoddard correlation sheets were used except for German 3 where the number of students taking the examination was only eleven. From the intercorrelation values obtained the value of IQ scores (yielded by the Otis S-A Tests of Mental

Ability: Higher A) for predicting success in the various high school subjects was calculated.

Subjects

The subjects serving throughout this investigation were selected from Grade XII students attending the Edmonton high schools (exclusive of the Separate high schools) during the school year 1931-32. The students considered were those who took the Otis Self-Administering Tests of Mental Ability, Higher Examination: Form A in May 1932 and who wrote at least one departmental examination in a Grade XII subject in June 1932.

For the purpose of this investigation a Grade XII pupil was defined as one who wrote at least one examination on a Grade XII subject, June 1932; and a Grade XII subject was defined as one of the following: Literature 4, Composition 4, History of English Literature 1, History 4, Algebra 3, Geometry 3, Trigonometry 1, Physics 2, Chemistry 2, Biology 1, Latin 3, French 3 and German 3.

The list of Edmonton high school pupils writing Grade XII examinations, June 1932, contained seven hundred and eighty-three (783) names. Of this number twenty-nine (29) names were dropped for reasons as follows: In twenty-eight cases no IQ rating was given, in the remaining case an IQ rating of 78 was given, while the average mark obtained by this student on nine (9) Grade XII examinations was 68.2. On investigation it was found that the pupil

in question was subject to seizures and that in all probability the test came on one of her bad days. The writer felt justified in dropping this case. The number of cases considered was, therefore, seven hundred and fifty-four (754).

Materials

The materials used in this investigation were IQ scores and marks. The IQ scores were obtained in the intelligence test survey of the Edmonton high schools in May 1932. The marks are those obtained by Grade XII students in the Edmonton high schools, June 1932. This material is summarized in the next chapter.

CHAPTER V

SUMMARY OF THE DATA

The IQ scores and marks on twelve of the Grade XII subjects were arranged on twelve (12) Ruch and Stoddard correlation sheets, the IQ along the X-axis and the marks along the Y-axis. The sheets contained IQ scores and marks for each of the following subjects: Literature 4, Composition 4, History of English Literature 1, History 4, Algebra 3, Geometry 3, Trigonometry 1, Chemistry 2, Physics 2, Biology 1, Latin 3 and French 3. For German 3, r was computed without tabulation of a correlation table.

The paired series of measures arranged on the different sheets were correlated, values being computed for r, P.E.$_r$, M_x and M_y, σ_x and σ_y (X = IQ, Y = Marks). Since correlation sheets were too large to be included tables containing a summary of the data were made from them and presented, as follows:

TABLE V

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A AND LITERATURE 4 MARKS

IQ (OTIS HIGHER A) May, 1932

MARKS (LIT. 4) June, 1932

	85	88	91	94	97	100	103	106	109	112	115	118	121	124	127	130	
94																1	1
90									1						1		2
86																1	1
82								1	2		1	3		1			8
78									1	2	2		2		3		11
74					1		1	1		2		4	1	6	1		17
70						1	3	2	1	2	6	2	3	2	3	1	26
66					1		3	4	4	5	2	6	3	4	1	1	34
62			1				1	3	10	4	3	4	3	3	3		35
58				1	1	4	3	4	2	7	5	2	9		3		41
54				1	3	3	2	3	3	6	6	1	4	3		1	36
50	2			2	3	3	13	10	10	11	12	9	4	10	2	1	92
46					1	1		1	2			2	1	2			10
42		1		1	3	1	4	2	2	5	7	1	3	1	1		32
38								1	1	2	4	2	1				11
34						1			2	3	4	2					12
30						1	1	3	2		1	1					9
26							1				1				1		3
22							1				1			1			3
18						2											2
	2	1	1	5	13	17	33	35	43	49	55	39	34	33	19	7	386

TABLE VI

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A AND COMPOSITION 4 MARKS

June, 1932.

MARKS (COMP. 4)

IQ (OTIS HIGHER A) May, 1932.

	82	85	88	91	94	97	100	103	106	109	112	115	118	121	124	127	130	
90											1	1			1			3
86																	1	1
82												1	1		1			3
78													1	1	1	3		6
74								2		1	1		1	2	1	2		10
70							1		1	1	3	1	3	2	3	2		17
66					1			1	1	3	4	1	3	2	2	1		19
62					1	1	2	5	2	3	4	8	6	5	5	1	1	44
58								3	5	5	4	5	4	4	6	2	2	40
54			1		2	2	1	7	3	7	6	10	2		2	1		44
50			1		1	2	2	6	5	12	5	8	7	6	3	1	1	60
46	1						2	2		1	3			1				10
42					1	3	2	2	5	4	3	1	3	1	2			27
38						1	2	2	4	1	3	2	2		2			19
34							1	1	2	2	2	2	1		1		1	13
30										1		2				1		4
26				1	1						3	2						7
22						1	1	2	1			1						6
18								2										2
14																		
10																		
6													1	1				2
	1		2	1	7	10	14	35	29	41	42	45	35	25	30	14	6	337

TABLE VII

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A AND HISTORY OF ENGLISH LITERATURE 1 MARKS

MARKS (HIST. OF ENG. LITERATURE 1) June, 1932

IQ (OTIS HIGHER A) May, 1932.

	83	86	89	92	95	98	101	104	107	110	113	116	119	122	125	128	131	
84												1						1
81												1		1				2
78						1												1
75						1								1				2
72									1	1	2		1				1	6
69						1	1	1	1			2	1					7
66								1	1		1	2						5
63									1	1		1	1	2				6
60							1		1	1		1		1				5
57							1					2			1			4
54		1				1	1			2	1	1				1		8
51						1	2	1		2	6				1			13
48					1	1	3	3	4	2		3						17
45	1																	1
42							1	1		1		1						4
39										3				1	1			5
36								1		1		1						3
33										1	1	1	1		1			5
30							1	1		1	1							4
27					1		1											2
24										1								1
21														1				1
18							1											1
15										1								1
	1	1			2	6	13	9	9	18	12	17	4	7	4	1	1	105

TABLE VIII

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A
AND HISTORY 4 MARKS

IQ (OTIS HIGHER A) May, 1932

MARKS (HISTORY 4) June, 1932

	81	84	87	90	93	96	99	102	105	108	111	114	117	120	123	126	129	132	
99										1									1
95																			
91												1					1		2
87								1			1		3	1	3	1	2		12
83						1	1		2		1		5	3	3				16
79									1		1	1		2	1	4	2		12
75							1		1	3	2	2	5	1	1	2	1		19
71						1	1	1	3	3	1	5	2	2	4	1	1	1	26
67								2	2	3	4	1	2	2		1		1	18
63						3	1	1	2	3	3	6	2	3	2	1	1		28
59						1	1	1		3	3	3	5	4	1	1			23
55						2		3	1	4	5	2	3	3	2	4	1		30
51						1	2	1	5	4	3	5	2	4	2	4			33
47					2			1		5	3	1	1	2	4	1			20
43			1		1		2		1	2	3	1	3	1	2		1		18
39							2	1	1	2	1	2	2	2	2				15
35	1					1			2	3		4	2		2				15
31		1			1		1	1		1	1	1	1		2				10
27										1	3	1				2			7
23									1			1	1						3
19																			
15															1				1
	1	1	1		4	10	12	13	22	38	35	37	39	30	32	22	10	2	309

TABLE IX

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A
AND ALGEBRA 3 MARKS

IQ (OTIS HIGHER A) May, 1932.

88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	
														1				1		1	1		4
											1	1	2			2		1	1	2	2	1	13
			1							1		2	1	3	1	1		3	3				16
					1			1							1	2	3		4	1		1	14
						1		2	1	3		2	4		2	1	2	3	1				22
							2	1	2	1	1	1	4	2		3	1	2	2	1			23
				1			2		1		1	5	4	1	5	5	4	4	1	2	4		40
				1	2			1	2		2	2	2	3	1	6	2	1	1	2			28
		2			2			1		2	2	3	2	7	3	5	1	1	2	2			35
						1		1	1	3	1	2	4	3	3	2	1	3					25
							1		1	1	2	6	2	1		1		2	1				18
1				1				1	3	2	1	1	1	1	1	3			1				17
				1			1	2	1	1	2	1	2		1		1	2	2		1		18
				1		1		1		1	4	4	1	4	1								18
							1	3	2		1	2	2		3	1	1	1					17
					1				1	1	1	1	2	1	1	1	2						12
			1			3		2		2	1			1		1				1			12
								1	1	1	1	1	2					1					8
										1				1				1					3
											1												1
1		2	2	5	6	6	7	17	16	20	22	34	35	29	23	34	18	26	19	12	8	2	344

TABLE X

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A
AND GEOMETRY 3 MARKS

June, 1932

MARKS (GEOMETRY 3)

	IQ (OTIS HIGHER A) May, 1932																	
	83	86	89	92	95	98	101	104	107	110	113	116	119	122	125	128	131	
99											2							2
94										1	5	2	1	2	1	1	1	14
89								1		1	1	4	2	2	1	3	1	16
84			1					4	1	2	4	6	4	1	6		1	30
79						3		1	2	1	2	1	1	1	2	1	1	16
74	1							2	3	2	5	9	4	3	2	2	1	34
69					1	1	1	1	2	6	5	2	6	3	2			30
64				1		1	2	1	4	3	4	1	1	3	1	2	1	25
59					1		3	2	1	2	3	2	7	2	5			28
54					1	1	2	3	2	3	2	2	5	1	6			28
49						2			1		1	1	1		1	1		8
44					1		1	1	2	2	2	3	2	2				16
39					2	2		1	2	3	2	1	1		2	1		17
34							1	3	1		3	1	1		2			12
29								2	3		1	1	1	1				9
24					1		1	2	2	4	2	1	1		1			15
19							1	1	1	1		1		1				6
14								2			1							3
9									2		1			1				4
4																		
-1												1						1
	1		1	1	7	10	12	27	29	31	46	39	38	23	32	11	6	314

TABLE XI

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A
AND TRIGONOMETRY 1 MARKS

June, 1932

MARKS (TRIGONOMETRY 1)

	IQ (OTIS HIGHER A) May, 1932																		
	82	85	88	91	94	97	100	103	106	109	112	115	118	121	124	127	130	
99							1				2	2	2		3	5	3	18
94								1	1	2	3	1	3	6	5	1	2	25
89						2	1	4	3	1	7	5	2	3	5	4	1	38
84						1		3	3	1	2	3	4	5	4		1	27
79						2	1	1	2	3	3	5	3	3	4	2	1	30
74			1	1					7	2	5	4	7	4	1	1		33
69							1	4		5	10	5	2	6	3	1		37
64			1		3	1			3	6	2	3	6		4	1	1	31
59					1	2	1	1	7	6	3	5	1	2	3	2		34
54						1	1	2	3	3	6	3	2	1	2	2		26
49			1		1		3	3	5	8	5	4	1	4	3	1		39
44					1		1	1		4		1	2		1			11
39	1							1	3	1	3	1	2					12
34			1			1			1	1		1		3		1		9
29						1	1	3	1									6
24					1		1		2	1	1							6
19							1					1						2
14							1		1				1	1				4
9																		
4									1	1		1						3
	1		4	1	7	11	14	24	43	45	52	45	38	38	38	21	9	391

TABLE XII

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A AND PHYSICS 2 MARKS

June, 1932.

MARKS (PHYSICS 2)

	IQ (OTIS HIGHER A) May, 1932.																		
	83	86	89	92	95	98	101	104	107	110	113	116	119	122	125	128	131	
95															1			1
90															2	1		3
85										1	1	1		2				5
80										1	3	3	1	1	3		1	13
75							1	1		2	4		1		1	1	1	12
70								2	1	1		4	6	3	1			18
65						2		2	5		6	8	3	2	5	2		35
60								2	2	5	8	9	5	3	7	3	1	45
55						1	1	2	4	4	7	5	11	3	3			41
50					1	1		3	4	6	6	2			1			24
45	1		1					1	5	3	1	3	1	4				20
40			1			1	3	2	4	3	1	4	3	1	1			24
35					2	1		2	3	2	1	2	1					14
30				1		1	1	2					2					7
25						1			1	1		2						5
20							1					1						2
15										1			1					2
10						1												1
5					1													1
	1		2	1	4	9	7	19	29	30	38	44	35	19	25	7	3	273

TABLE XIII

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A
AND CHEMISTRY 2 MARKS

IQ (OTIS HIGHER A) May, 1932

89	91	93	95	97	99	101	103	105	107	109	111	113	115	117	119	121	123	125	127	129	131	
												1		1			1					3
							1					1	1	1				1	1			6
											1	1		2			3	1	1			9
						1		1				2	1	1		2	2		2			12
								1	3	1		2	1	2					2			12
1			1		1		1	2	2	1	1	2	1	2	1			1		1		18
							1	2			3					2	2	2		1		13
									1		1	2	3	1	1	1	1	2			1	14
		1		1	1			1	1	1	2		5		1	1	1	2				18
				2	1	1	4		1	1		2	1	1	2				1			17
			1				1		1	2		1	1	1	1	1	2	1				13
							1	1	2	1	4	1				1	1	1				13
1				1	1			2	1			1			1	1		1				10
						1		1	1	2		1	1				1					8
								1	1	1	1	1			3							8
						1	1	1					1									4
					1																	1
											1											1
														1								1
2		1	2	4	5	4	10	13	14	10	14	18	16	13	10	9	14	12	7	2	1	181

TABLE XIV

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A
AND BIOLOGY 1 MARKS

June, 1932.

MARKS (BIOLOGY 1)	IQ (OTIS HIGHER A) May, 1932																		
	83	86	89	92	95	98	101	104	107	110	113	116	119	122	125	128	131	
88								1							1			2
85															1			1
82												4	1			2		7
79														1				1
76						1		1		1	1			1	1			6
73						1	1		1		1			1	1			6
70					1		1	2		2		1					1	8
67									3	2	1	2		1	1			10
64						3		3	3	1	1	2	2	1	1			17
61				1		2			2	2	2	4			1			14
58						1	2					3	1					7
55						1	1		1	3		1						7
52						1	3	1				1	1	1	1			9
49					1	1				1	1	3	2					9
46						1		1				1						3
43										1		1	1					3
40							1	1	1	1	1	1						6
37	1																	1
34																		
31									1									1
28																		
25										1								1
	1			1	2	12	9	10	12	15	8	24	8	6	8	2	1	119

TABLE XV

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A
AND LATIN 3 MARKS

IQ (OTIS HIGHER A) May, 1932

MARKS (LATIN 3) June, 1932

	95	97	99	101	103	105	107	109	111	113	115	117	119	121	123	125	127	129	131	133	
90																		1	1	1	3
86										1	1						1	1			4
82			1			1			1				1								4
78									1						4	2	1	2		1	11
74								1	2	1	2		1		1		2				10
70						1				1		1		1	2	1					7
66		1						1	2	2				1	2				1		10
62							1	1		1	2	1	1	3	1	2		1			14
58		1			1			3		3	3	1	1					1			14
54					2				1	2	1	1	2		2						11
50					1	2	1	1	1		1	2		1	2						12
46								1		1											2
42		1	1	1	2		1	2		1		2		1	1			1			14
38	1					1	2	1	1	1	1										8
34										2	1			1							4
30											1						1				2
26																1					1
22			1																		1
18								1													1
	1	3	3	1	6	5	5	12	9	16	13	8	6	8	15	6	5	7	2	2	133

TABLE XVI

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A
AND FRENCH 3 MARKS

IQ (OTIS HIGHER A) May, 1932

92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	
																1					1
												1		1							2
					1					1						1					3
			1	1			1			1	1		1				2				8
										2		1	1	2	1				1		8
			1						1	1			1	2	2		3	3		1	15
							2		3	1		1	4	2	1	2	2				18
			2	1		1	2	3	1	3	4	4	1	1	3		3	1	1		31
		1			1		5	3	1	2	2	3	6	5	1	1	2	2			35
		1	1	2	1	3	5	3	3	4	4	3	3	5	2		3	2			45
1			2	1	1	3	3	5	3	5	6	5	4	1		3	1				44
	2	1	1		2	1	2	3	2		3	2		2		3		1			25
				1	3	4	2	2	1	1	1	3		1							19
	1		1		1	1			3	1		2	1	1							12
							1			1	1	1	1	2							7
									1					1							2
								1							1						2
									1												1
1	3	3	9	6	10	13	23	20	20	23	22	26	23	26	11	11	16	9	2	1	278

TABLE XVII

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A AND GERMAN 3 MARKS

MARKS (GERMAN 3) June, 1932 \ IQ (OTIS HIGHER A) May, 1932	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	
86									1										1
82															1				1
78																			
74													1						1
70	1																		1
66																		1	1
62											1	1			1				3
58															1				1
54										1									1
50																			
46																			
42																			
38																			
34																			
30																			
26																			
22																			
18																			
14																			
10								1											1
	1							1	1	1	1	1	1		3			1	11

CHAPTER VI

QUANTITATIVE ANALYSIS OF THE DATA

Correlation

A correlation may be thought of as the decimal fraction which tells us what proportion of the causes affecting the magnitude of the two variables is common to both variables. The results of the correlations, based on the data of Tables V--XVII, are as follows:

Table V, IQ vs Marks (Lit. 4).- Three hundred and eighty-six (386) pupils wrote the Literature 4 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.24 ± 0.03. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 83 to 132 with a mean score of 114.25 and a standard deviation of 8.76; on the Literature 4 Marks (June 1932) from 20 to 95, with a mean score of 57.36 and a standard deviation of 13.08.

Table VI, IQ vs Marks (Comp. 4).-Three hundred and thirty-seven (337) pupils wrote the Composition 4 examination. The Pearson r representing the degree of relationship between the two paired series of scores is 0.30 ± 0.03. The two series of measurements may be summarized as follows: The range in IQ score values on IQ testing (May 1932) was from 84 to 132 with a mean score of 113.78 and a standard deviation of 8.85; on the Composition 4 Marks (June 1932) from 7 to 90, with a mean score of 55.17 and a standard deviation of 13.52.

Table VII, IQ vs Marks (Hist. of Eng. Lit. 1).-One hundred and five (105) pupils wrote the History of English Literature 1 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.14 ± 0.07. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 83 to 131 with a mean score of 11.56 and a standard deviation of 8.61; on the History of English Literature 1 Marks (June 1932) from 16 to 85 with a mean score of 53.64 and a standard deviation of 14.67.

Table VIII, IQ vs Marks (Hist. 4).-Three hundred and nine (309) pupils wrote the History 4 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.20 ± 0.04. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 83 to 132 with a mean score of 114.89 and a standard deviation of 9.12; on the History 4 Marks (June 1932) from 15 to 100 with a mean score of 60.06 and a standard deviation of 16.36.

Table IX, IQ vs Marks (Alg. 3).-Three hundred and forty-four (344) pupils wrote the Algebra 3 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.31 ± 0.03. The two series of measurements may be summarized as follows:

The range in IQ score values on the IQ testing (May 1932) was from 88 to 132 with a mean score of 115.81 and a standard deviation of 8.48; on the Algebra 3 Marks (June 1932) from 0 to 100 with a mean score of 59.81 and a standard deviation of 21.70.

Table X, IQ vs Marks(Geom. 3).-Three hundred and fourteen (314) pupils wrote the Geometry 3 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.23 ± 0.04. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 83 to 132 with a mean score of 115.15 and a standard deviation of 8.76; on the Geometry 3 Marks (June 1932) from 1 to 100 with a mean score of 63.17 and a standard deviation of 21.50.

Table XI, IQ vs Marks (Trig. 1).-Three hundred and ninety-one (391) pupils wrote the Trigonometry 1 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.32 ± 0.03. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 83 to 132 with a mean score of 114.58 and a standard deviation of 9.03; on the Trigonometry 1 Marks (June 1932) from 4 to 100 with a mean score of 69.34 and a standard deviation of 20.30.

Table XII, IQ vs Marks (Phys. 2).-Two hundred and seventy-three (273) pupils wrote the Physics 2 examination. The

Pearson r representing the degree of relationship between the two paired series of scores is positive 0.42 ± 0.03. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 83 to 132 with a mean score of 115.04 and a standard deviation of 8.34; on the Physics 2 Marks (June 1932) from 5 to 95 with a mean score of 58.14 and a standard deviation of 15.30.

Table XIII, IQ vs Marks (Chem. 2).-One hundred and eighty-one (181) pupils wrote the Chemistry 2 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.26 ± 0.05. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 90 to 132 with a mean score of 114.03 and a standard deviation of 8.76; on the Chemistry 2 Marks (June 1932) from 22 to 96 with a mean score of 64.22 and a standard deviation of 15.80.

Table XIV, IQ vs Marks (Biol. 1).-One hundred and nineteen (119) pupils wrote the Biology 1 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.26 ± 0.06. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 84 to 131 with a mean score of 112.28 and a standard deviation of 9.03; on the Biology 1 Marks (June 1932) from 26 to 85 with a mean score of 62.68 and a standard deviation of 12.39.

Table XV, IQ vs Marks (Lat. 3).-One hundred and thirty-three (133) pupils wrote the Latin 3 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.39 ± 0.05. The two series of measurements may be summarized as follows: The range of IQ score values on the IQ testing (May 1932) was from 96 to 134 with a mean score of 116.42 and a standard deviation of 8.62; on the Latin 3 Marks (June 1932) from 20 to 91 with a mean score of 60.72 and a standard deviation of 15.76.

Table XVI, IQ vs Marks (Fr. 3).-Two hundred and seventy-eight (278) pupils wrote the French 3 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.26 ± 0.04. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 93 to 132 with a mean score of 114.36 and a standard deviation of 8.38; on the French 3 Marks (June 1932) from 17 to 92 with a mean score of 56.09 and a standard deviation of 11.56.

Table XVII, IQ vs Marks (Ger. 3).-Eleven (11) pupils wrote the German 3 examination. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.14 ± 0.20. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 86 to 121 with a mean score of 107.45 and a standard deviation of 5.84; on the German 3 Marks (June 1932) from 10 to 89 with a mean score of 64.45 and a standard deviation of 13.08.

TABLE XVIII#

SUMMARY OF CORRELATIONS BASED ON MATERIAL IN TABLES V--XVII

SUBJECT	NO.	MEANS		DEVIATIONS		CORRELATION COEFFICIENT (r)
		M_x	M_y	σ_x	σ_y	
Lit. 4	386	114.27	57.36	8.76	13.08	0.24 ± 0.03
Comp. 4	337	113.78	55.17	8.85	13.52	0.30 ± 0.03
Hist. of Eng. Lit.	105	111.56	53.64	8.61	14.67	0.14 ± 0.07
Hist. 4	309	114.89	60.06	9.12	16.36	0.20 ± 0.04
Alg. 3	344	115.81	59.81	8.48	21.70	0.31 ± 0.03
Geom. 3	314	115.15	63.17	8.76	21.50	0.23 ± 0.04
Trig. 1	391	114.58	69.34	9.03	20.30	0.32 ± 0.03
Phys. 2	273	115.04	58.14	8.34	15.30	0.42 ± 0.03
Chem. 2	181	114.03	64.22	8.76	15.80	0.26 ± 0.05
Biol. 1	119	112.28	62.68	9.03	12.39	0.26 ± 0.06
Lat. 3	133	116.42	60.72	8.62	15.76	0.39 ± 0.05
Fr. 3	278	114.36	56.09	8.38	11.56	0.26 ± 0.04
Ger. 3	11	107.45	64.45	5.84	13.08	0.14 ± 0.20
Aver.		113.82	60.37	8.51	15.77	0.27 ± 0.04

No. = No. of pupils writing examination
x = IQ scores (Otis Higher A)
y = Marks on departmental examination
σ_x = Standard deviation of x
σ_y = Standard deviation of y

#. Table XVIII contains a summary of the thirteen correlations described above.

Prediction

One of the chief purposes of correlation is for use as a measure of the degree to which one measure can be predicted from another. If we wish to find the predictive value of intelligence tests, we must have some measure of scholarship, with which to correlate the score. As a measure of relative success in this investigation we used the marks the students made in the final Grade XII examinations at the end of the school year. This measure of success is called the criterion. The value of the test is judged principally by the degree to which it correlates with the criterion.

One measure of the predictive values of scores is called the coefficient of alienation. The greater this coefficient is, the less is the predictive value. We represent the coefficient of alienation by the letter k. If $k = 1.00$, there is no predictive value at all. If $k = 0$, prediction is perfect. k may be calculated very simply from the coefficient of correlation, for $k = \sqrt{1 - r^2}$. The percent of forecasting efficiency of the scores is 100 - k (where k is expressed as a percent).

The method of finding the prognostic value of an intelligence test, just explained, was used in this investigation. Tables XIX and XX, which follow immediately, are the result of applying Kelley's formula for the coefficient of alienation ($k = \sqrt{1 - r^2}$), and then deducting this alienation coefficient from 100%. This difference expressed as a percent represents the forecasting efficiency of the

correlation coefficient. Table XIX gives the predictive values for the correlations found between IQ Scores and Examination Marks, and Table XX gives a practical interpretation of the predictive values found from correlations ranging from 1.00 to .1, as follows:

TABLE XIX

SHOWING THE FORECASTING EFFICIENCY FOR CORRELATION COEFFICIENTS--IQ VS MARKS

IQ VS MARKS FOR SUBJECTS:	r	$\sqrt{1 - r^2}$ (k)	% FORECASTING EFFICIENCY
Lit. 4	0.24	0.97	3
Comp. 4	0.30	0.95	5
Hist. E. Lit. 1	0.14	0.99	1
Hist. 4	0.20	0.98	2
Alg. 3	0.31	0.95	5
Geom. 3	0.23	0.97	3
Trig. 1	0.32	0.95	5
Phys. 2	0.42	0.91	9
Chem. 2	0.26	0.97	3
Biol. 1	0.26	0.97	3
Lat. 3	0.39	0.92	8
Fr. 3	0.26	0.97	3
Ger. 3	0.14	0.99	1

TABLE XX

PRACTICAL INTERPRETATION OF THE PER CENT OF FORECASTING EFFICIENCY FOR DIFFERENT VALUES OF r.

COEFFICIENT OF CORRELATION	PER CENT OF FORECASTING EFFICIENCY	PRACTICAL INTERPRETATION
1.00	100	
.99	86	Evidence of unusual relationship; marked prognostic value.
.98	80	
.95	69	
.90	56	
.866	50	
.80	40	
.75	34	Evidence of a marked relationship; of rather marked pronostic value.
.70	29	
.65	24	Evidence of a real relationship; of limited usefulness for prognostic purposes.
.60	20	
.50	13	Evidence of some relationship; possibly useful.
.40	8	Practically useless for forecasting purposes (less than 13% effective)
.30	5	
.20	2	
.10	½	

The above table is a combination of two tables. Greene and Jorgensen, "The Use and Interpretation of Educational Tests", pp. 162-163.

A second method of finding the predictive value of scores is based on the observation that in a random distribution there is a regression or stepping back of the variable towards the general average. The lines representing this general tendency are called lines of regression. Their equations are given by Karl Pearson. By using these formulae we find the most probable value of one variable corresponding to a given value of the other.

Thus#, for a person whose IQ (x_1) is 110 the most probable mark (y_1) will be found, as follows:

$$y_1 = r \frac{\sigma_y}{\sigma_x} (x_1 - \bar{x}) + \bar{y}$$

$$= .24 \frac{13.08}{8.76} (110 - 114.27) + 67.36$$

$$= 55.83. \qquad (1)$$

By using the formula for the probable error of an estimated score, we find:

$$\text{P.E.(est.score)} = .6745 \frac{\sigma_x + \sigma_y}{2} \sqrt{1 - r^2}$$

$$= .6745 \frac{8.76 + 13.08}{2} \sqrt{1 - (.24)^2}$$

$$= 7.14. \qquad (2)$$

Combining (1) and (2) we find the estimated mark in Lit. 4 for a pupil whose IQ is 110, as follows:

$$\text{Lit. 4(est.mark)} = 55.83 \pm 7.14. \qquad (3)$$

This means that the chances are 1:1 that the mark of this pupil lies between 55.83 + 7.14 and 55.83 - 7.14; i.e., between 62.97 and 48.69.

#. This calculation was based on data given in Table XVIII, p. 41.

The chances are about 4:1 that the mark lies between 55.83 + 2(7.14) and 55.83 - 2(7.14); i.e., between 70.11 and 41.55.

The chances are about 20:1 that the score lies between 55.83 + 3(7.14) and 55.83 - 3(7.14); i.e., between 77.25 and 34.41.

This method was used for computing the scores for each of the other Grade XII subjects, for a student having the same IQ (110). The complete results are given in Table XXI, which follows:

TABLE XXI[#]

ESTIMATED SCORES FOR A GRADE XII STUDENT, IQ = 110, DEPARTMENTAL EXAMINATIONS--1932

SUBJECT	MOST PROBABLE SCORE (y_1)	PROBABLE ERROR (P.E.)	ESTIMATED SCORE ($y_1 \pm$ P.E.)
Lit. 4	55.83	7.14	55.83 ± 7.14
Comp. 4	53.44	7.17	53.44 ± 7.17
Hist. of Eng. Lit. 1	53.27	7.77	53.27 ± 7.77
Hist. 4	58.31	8.42	58.31 ± 8.42
Alg. 3	55.20	9,67	55.20 ± 9.67
Geom. 3	60.26	9.90	60.26 ± 9.90
Trig. 1	66.05	9.40	66.05 ± 9.40
Phys. 2	54.26	7.26	54.26 ± 7.26
Chem. 2	62.33	8.03	62.33 ± 8.03
Biol. 1	61.87	7.01	61.87 ± 7.01
Lat. 3	56.14	7.56	56.14 ± 7.56
Fr. 3	54.53	6.52	54.53 ± 6.52
Ger. 3	65.25	6.32	65.25 ± 6.32

$$y_1 = r \frac{\sigma_y}{\sigma_x} (x_1 - \bar{x}) + \bar{y}$$

$$\text{P.E.} = .6745 \frac{\sigma_x + \sigma_y}{2} \sqrt{1 - r^2}$$

x_1 = Assumed IQ

$\bar{x}$ = Mean IQ

$\bar{y}$ = Mean Mark

σ_x = Standard Deviation of x scores (IQ)

σ_y = Standard Deviation of y scores (Marks)

#. The data, from which these results are calculated, are given in Table XVIII, page 41.

Conclusions

If we make use of Table XX in interpreting the results obtained by using Kelly's formula for predictability (Table XIX), we see that since r is always less than 0.50, the forecasting efficiency of our highest measure is always less than 13%, which is practically useless. Wood says, "In the matter of predicting academic achievement, the intelligence test stands without a serious rival."[1] The Otis S-A Test of Mental Ability: Higher A does not seem to have been particularly successful in predicting the academic achievement of Edmonton Grade XII students, as measured by the marks obtained by them on departmental examinations, June 1932.

If we examine the results obtained by the second method of predictability (preceding page), we see that the magnitude of the probable error is from 7.01--9.90. This indicates the uncertainty of prediction based upon correlation values as low as those found in this study.

Having found the value of the intelligence test, used in our investigation, to be very low in predicting achievement in the later years of high school, it seemed desirable to see how its predictive value compared with that of marks obtained on earlier departmental examinations in the same subject. The following chapter was, therefore, devoted to this study.

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1. Wood, "Measurement in Higher Education", p. 274.

CHAPTER VII

AN EXTENSION OF THE INVESTIGATION

In judging the worth of a new instrument it is often more meaningful to compare its results with those of the old instruments which it is to displace or supplement than to learn how far short of prediction its results fall. The presentation of the data which follows is prompted by the desire to define more clearly the efficiency of the intelligence test as a criterion for the prediction of achievement in the later years of high school.

In comparing the predictive value of the Otis Higher A Tests with that of the traditional content examination, the comparisons here made are with Algebra 1 and Algebra 2 departmental examination marks in predicting success in Algebra 3. "To predict success in a special subject one would use data that have something in common with the particular subject being predicted."[1] Symonds warns us that "it is a mistake to assume that each subject predicts best that subject which has the same name. The work of Gowan and Gooch shows the fallacy in such an assumption."[2] It was thought that the data of Algebra 1 and Algebra 2 would have more in common with that of Algebra 3 than any other

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1. Symonds, "Measurement in Secondary Education", p. 405
2. ibid..... p.431

data, since the subject matter of Algebra is fairly continuous throughout the high school course.

Methods, Subjects, Materials

Methods.-Armed with the list containing the names, IQ's, and departmental examination marks for the 344 Edmonton high school pupils who wrote Algebra 3 in June, 1932, the investigator visited some of the city high schools to seek in their records, files, etc. Algebra 1 and Algebra 2 marks for as many of the 344 as could be found. Before beginning this work it was necessary to decide which Algebra 1 and Algebra 2 marks she would look for. It was found that certain students had 2, 3, or 4 different marks in each class which meant 1, 2, or 3 failures in the subject for these students. The first plan was to find the first mark(whether passing or failing) in Algebra 1 and Algebra 2 for each student. This plan was followed in about a dozen cases but the writer, knowing neither when the pupils entered the school nor where they came from, could not be certain whether the mark she had so diligently sought was the first, second or third. Accordingly this plan was given up and the method adopted of considering only those pupils on our list for whom a passing mark in both Algebra 1 and Algebra 2 could be found. The chief objection to this method was that the time factor was not considered. It was realized that one should not pool Algebra marks obtained after one, two, three or four years of study of the subject. Some system of weighting marks inversely as to the time factor should have been worked

out and applied to the measures but, unfortunately, the time could not be definitely ascertained in many cases.

However, since the investigator had decided to compare the predictive value of marks with that of IQ's, she chose what seemed the better of the two methods and proceeded with the investigation. For that matter, she did not know whether the 1932 departmental examination marks in her possession represented first, second, third or fourth trials. In all probability, the Algebra 1 and Algebra 2 marks were just as reliable as the Algebra 3 marks. Accordingly, passing marks in Algebra 1 and Algebra 2 were entered on the list for as many of the 344 as could be found.

Subjects.-The subjects serving in this minor investigation were 144 of the 344 who wrote the Algebra 3 departmental examination in 1932. They were chosen irrespective of whether they passed or failed Algebra 3.

Materials.-The materials used were Algebra 1 (passing) marks, Algebra 2 (passing) marks and Algebra 3 (June, 1932) marks for 144 Edmonton high school pupils.

Summary of Data

The data collected for this investigation were arranged on three (3) Ruch and Stoddard Correlation Sheets: Marks (Algebra 1) vs Marks (Algebra 2); Marks (Algebra 1) vs Marks (Algebra 3); Marks (Algebra 2) vs Marks (Algebra 3). The distributions are shown in tabular form (Tables XXII-XXIV), as follows:

TABLE XXII

ALGEBRA 1 AND ALGEBRA 2 MARKS
DEPARTMENTAL EXAMINATIONS

MARKS (ALGEBRA 2)

MARKS (ALGEBRA 1)	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96	99	
98													1		2		1		4
95																1	1	1	3
92															1				1
89				1			1		1	1					2				6
86	1		1	1		2					1		1	1		2			10
83	1		1	1	1		1		1	1	1			1					9
80		1		2					1		1		1	1	1	1	2		11
77					1			2			1			1	2	1	1		9
74								1		1	2					1		1	6
71	2		2			1	1	1	1	1				1	1	1			12
68	1		1	1		3	1	1	2		1							1	12
65	1		2			1						1		1	1				7
62	1	1		1	1		1			1		2	1						9
59	1		2	1	3			1	1			1							10
56		1		2										1					4
53	2	1	1	4			1	1	2		1	1							14
50	3	3	2	2	1	1	1	1	2					1					17
	13	7	12	16	7	8	7	8	11	5	8	5	4	8	10	7	5	3	144

TABLE XXIII

ALGEBRA 3 AND ALGEBRA 2 MARKS
DEPARTMENTAL EXAMINATIONS

MARKS (ALGEBRA 2)

MARKS (ALGEBRA 3)	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96	99	
96	1													1		2		1	5
91				1									1		2	1	1	2	8
86											1		1		3		1		6
81			1			1			1				1	1			1		6
76	1		1				1			2	1	2		1	1		1		11
71		2		2		2	2	1	3		2	1	1		1				17
66				3			1	1	1	1	1			2			1		11
61	2	3	3	1	2	1	1	1				1		1		1			17
56	3		1	1	1	1	1	1	3		1			2	1	2			18
51	1			1		1	1		1										5
46			2	1	1														4
41		1			1	2			1	2					1	1			9
36			1	2					1										4
31	1		1	2	1			2				1			1				9
26	2			1							2								5
21		1	1	1				2											5
16	1																		1
11			1																1
6					1														1
1																			
0	1																		1
	13	7	12	16	7	8	7	8	11	5	8	5	4	8	10	7	5	3	144

TABLE XXIV

ALGEBRA 3 AND ALGEBRA 1 MARKS
DEPARTMENTAL EXAMINATIONS

MARKS (ALGEBRA 3)	MARKS (ALGEBRA 1)																		
	50	53	56	59	62	65	68	71	74	77	80	83	86	89	92	95	98	
96		1									1		1			2		5
91							2	1	1							1	3	8
86								1	1	1	1		1	1				6
81	1			1	1						1		1				1	6
76	2	2	1		1	1	2			1				1				11
71	3	1		1			1	2		1	4	2		2				17
66	1		1	1	1			2			2	1	1	1				11
61	2	2	1	2	3	1		3		1		1	1					17
56	1	3		2		1	3		3	3			2					18
51							2				1	1		1				5
46				1		1						1	1					4
41	1	1				2	2	1				1	1					9
36	1			1	1								1					4
31	1	2	1	1	1	1						1			1			9
26	1	1						1		1	1							5
21	2	1						1	1									5
16	1																	1
11												1						1
6										1								1
1																		
0					1													1
	17	14	4	10	9	7	12	12	6	9	11	9	10	6	1	3	4	144

Quantitative Analysis of the Data

Correlation.-The paired series of measures found in Tables XXII--XXIV were arranged on three (3) Ruch and Stoddard correlation sheets, and values computed for r, $P.E._r$, M_x and M_y, σ_x and σ_y. The results of the different correlations are as follows:

Table XXII, Algebra 2 Marks vs Algebra 1 Marks.-One hundred and forty-four (144) pupils passed both Algebra 1 and Algebra 2 examinations. The Pearson r representing the degree of relationship between the two sets of marks is positive 0.47 ± 0.04. The two series of measurements may be summarized as follows: The range in Algebra 2 marks was from 50 to 100 with a mean score of 71.19 and a standard deviation of 15.33; on Algebra 1 marks from 50 to 100, with a mean score of 71.04 and a standard deviation of 13.68.

Table XXIII, Algebra 2 Marks vs Algebra 3 Marks.-One hundred and forty-four (144) pupils wrote both Algebra 2 and Algebra 3 examinations. The Pearson r representing the degree of relationship between the two sets of marks is positive 0.46 ± 0.04. The two series of measurements may be summarized as follows: The range in Algebra 2 marks was from 50 to 100 with a mean score of 71.19 and a standard deviation of 15.33; on Algebra 3 marks (1932) from 0 to 100, with a mean score of 61.66 and a standard deviation of 21.30

Table XXIV, Algebra 1 Marks vs Algebra 3 Marks.-One hundred and forty-four (144) pupils wrote both Algebra 1 and Algebra 3 examinations. The Pearson r representing the degree of relationship between the two sets of marks is positive 0.28 ± 0.05. The two series of measurements may be summarized as follows: The range in Algebra 1 marks was from 50 to 100 with a mean score of 71.04 and a standard deviation of 13.68; on Algebra 3 marks (1932) from 0 to 100, with a mean score of 61.66 and a standard deviation of 21.30.

Summary.-Table XXV contains a summary of the three correlations described above, as follows:

TABLE XXV

SUMMARY OF CORRELATIONS BASED ON MATERIAL IN TABLES XXII--XXIV

MARKS	NO.	MEANS		DEVIATIONS		CORRELATION COEFFICIENT (r)
		M_x	M_y	σ_x	σ_y	
Alg. 2 vs Alg. 1	144	71.19	71.04	15.33	13.68	0.47 ± 0.04
Alg. 2 vs Alg. 3	144	71.19	61.66	15.33	21.30	0.46 ± 0.04
Alg. 1 vs Alg. 3	144	71.04	61.66	13.68	21.30	0.28 ± 0.05

Multiple Correlation#.-Table XXV shows that Algebra 2 correlates with Algebra 3 to the extent of .46 and Algebra 1 with Algebra 3 to the extent of .28. Our next problem is to determine whether the results of a test correlating .28 would add anything of value to the results of a test that correlated .46 with the criterion. We have a formula for finding the

#. Otis, Arthur., "Statistical Method in Educational Measurement," Chapter XIX, pp. 238-239.

correlation which it is possible to get between the combined score in the two tests and a criterion without actually combining the scores. This kind of correlation is called a multiple correlation.

In order to find the correlation between the combined score in two tests and a criterion, it is necessary first to find the correlation between the tests themselves. In our case, for Algebra 1 vs Algebra 2, r is .47. We may then substitute the three correlations in a formula and find the coefficient of multiple correlation.

The three coefficients of correlation may be represented as follows:

Correlation between Criterion (Alg.3) and Test 1 (Alg. 2) $= r_{c1} = 0.46.$

Correlation between Criterion (Alg.3) and Test 2 (Alg. 1) $= r_{c2} = 0.28$

Correlation between Test 1 (Alg. 2) and Test 2 (Alg. 1) $= r_{12} = 0.47.$

Let us represent the highest correlation that is possible between a combined score in Tests 1 and 2 and the criterion by the symbol $R_{c.12}$. Then

$$R_{c.12} = \sqrt{\frac{r_{c1}^2 + r_{c2}^2 - 2r_{c1} \cdot r_{c2} \cdot r_{12}}{1 - r_{12}^2}}$$

Substituting in this formula the values r_{c1}, r_{c2} and r_{12} given above, we have

$$R_{c.12} = \sqrt{\frac{(.46)^2 + (.28)^2 - 2 \times .46 \times .28 \times .47}{1 - (.47)^2}}$$

$$= .47$$

This shows that by properly combining the scores in Tests 1 and 2, which correlate .46 and .28 respectively with the criterion, and .47 with each other, it would be possible to get a correlation of .47 between the combined score and the criterion. The combined score, therefore, would be a slightly better prediction of success in Algebra 3 than either Algebra 2 or Algebra 1 alone.

Prognosis.-Throughout this investigation our chief concern is with the predictive values of the correlations found. The measure of this value was found by means of the coefficient of alienation technique. Table XXVI is the result of applying Kelley's formula for the Coefficient of Alienation ($k = \sqrt{1 - r^2}$), and then deducting this alienation coefficient from 100%. This difference expressed as a per cent represents the prognostic value of the correlation coefficient. Table XXVI gives the efficiency of Algebra 1 Marks, of Algebra 2 Marks, also of the combined score of Algebra 1 and Algebra 2 Marks for forecasting Algebra 3 Marks, as follows:

TABLE XXVI

SHOWING THE FORECASTING EFFICIENCY FOR CORRELATION COEFFICIENTS--MARKS VS MARKS

MARKS VS MARKS ALGEBRA	r	$\sqrt{1 - r^2}$ (k)	% Forecasting Efficiency
Alg.2 vs Alg.3	.46	.89	11
Alg.1 vs Alg.3	.28	.96	4
	$R_{c.12}$		
Alg. 1 + Alg.2 vs Alg.3	.47	.88	12

Conclusions.-If we make use of Table XX, p. 45 in interpreting the results of this investigation, as found in Table XXVI, we see that since r, in both cases, and $R_{c.12}$ is always less than 0.50, the forecasting efficiency is always less than 13%, which is practically useless. It should also be noted that the combined score of Algebra 1 and Algebra 2 Marks increased the predictability only 1% above that of Algebra 2 marks alone. We conclude, that when either r_{c1} or r_{c2} is very small, and r_{12} is small, the value of $R_{c.12}$ will not greatly exceed that of the greater single correlation. In such cases it is useless to find the multiple correlation of the combined scores with the criterion.

CHAPTER VIII

COMPARISONS

Many investigators have used intelligence test scores as bases for predicting success in high school[1] and college.[2] Several have used elementary school records as a basis of prediction for high school success,[3] and high school records as a basis for predicting college success.[4] And some have used both intelligence tests and marks, and showed their relative values for predicting achievement in high school[5] or college.[6]

Insofar as the writer was able to discover in the literature of educational measurements, very few investigators distinguished between the problem of predicting success for the high school freshmen and that of predicting success for the high school senior. Ross and Hooks[7] made this

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1. Proctor, W.M., "Psychology Tests in Guidance of High School Pupils," pp. 11, 15, 16.
2. Toops, H. A., "The Status of University Intelligence Tests in 1923-24," J. Ed. Psych., 1926, (17), pp. 23-26, pp. 110-124.
3. Ross, C. C., "The Relation between Grade School Record and High School Achievement," p. 23.
4. MacPhail, A.H., "Intelligence of College Students," (1924).
5. (a) Kelley, T.L., "Educational Guidance," Ch. 17.
   (b) Fretwell, E.K., "A Study in Educational Prognosis," (1919), pp. 39, 41.
6. Wood, B.D., "Measurement in Higher Education," p. 87.
7. Ross, C.C. and Hooks, N.T., "How Shall We Predict High School Achievement?" Univ. of Kentucky, J. Ed. Res., 1930 (22), pp. 184-196.

distinction but limited their study to that of predicting success for the high school entrant. Ross has made an extensive study of the value of elementary school records for predicting high school success[1] but he only considers one or two years of senior high school. Ross and Hooks refer to an investigation by Brooks[2] in which he compiled data showing that the achievement of pupils in the later years of high school in English, foreign languages, mathematics, social and natural sciences can be predicted better by the marks received in the same subject during the previous year than by a general intelligence test.

Comparison of Minor with Major Investigation

At this point it is interesting to recall the results of our supplementary investigation--finding the predictive value of marks obtained in previous units of the same subject--and to compare the results with those of the major investigation--finding the value of IQ scores for predicting achievement in the later years of high school. In our minor experiment we used three sets of marks, Algebra 1, Algebra 2 and Algebra 3 for 144 of the pupils who wrote Algebra 3 in June 1932. For

Algebra 1 vs Algebra 2, $r = 0.47 \pm 0.04$

Algebra 2 vs Algebra 3, $r = 0.46 \pm 0.04$

Algebra 1 vs Algebra 3, $r = 0.28 \pm 0.05$

Algebra 1 + Algebra 2 vs Algebra 3, $R_{3.12} = 0.47$

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1. Ross, C.S., "The Relation between Grade School Record and High School Achievement."
2. Brooks, S.S., "Some Uses for Intelligence Tests," J. Ed. Res., 1922 (5), pp. 217-238.

In order to make our comparisons as valid as possible, a new correlation was worked out between IQ and Algebra 3 marks for the 144 subjects who served in the minor investigation. For the purpose of completing this comparison, the result of that correlation will be used here and Table XXVI with complete summary will be presented at the close of the comparison. The Pearson r representing the degree of relationship between the IQ Scores and Marks (Algebra 3) was 0.28 ± 0.04.

Comparing this result with those given above, we see that the coefficient of correlation between IQ Scores and Algebra 3 Marks is just equal to the coefficient of correlation between Algebra 1 and Algebra 3 Marks, is less than that between Algebra 2 and Algebra 3 Marks, and less than the coefficient of multiple correlation between (Algebra 1 + Algebra 2) and Algebra 3. These results are in agreement with those of Brooks, namely, that the achievement of pupils in the later years of high school in mathematics (Algebra) can be predicted better by the marks received in the same subject during the previous year than by a general intelligence test.

Table XXVII together with a complete summary will now be presented:

TABLE XXVII

IQ SCORES ON OTIS HIGHER EXAMINATION: FORM A AND MARKS (ALGEBRA 3)

June, 1932

MARKS (ALGEBRA 3)

	OTIS (HIGHER A) SCORES														May 1932.
	92	95	98	101	104	107	110	113	116	119	122	125	128	131	
96							2	1				1		1	5
91								1	2	1	2	1	1		8
86					1			1			2	2			6
81					1	1		1				2		1	6
76						1	1	2	1	2	3	1			11
71				2		2	2	6		2	2		1		17
66			2		1			3		3		1	1		11
61	1				2	1	3		4	3	1	1	1		17
56	1				2	1	2	1	5	4		2			18
51						1	1	1	1			1			5
46					2			1				1			4
41				1	2	1		1	1	2		1			9
36					1			1	1		1				4
31		1		1		1	2	2		1	1				9
26			1		2				1		1				5
21			1	1		1		1	1						5
16										1					1
11											1				1
6									1						1
1															
-4							1								1
	2	1	4	5	14	10	14	23	18	19	14	14	4	2	144

Table XXVII, IQ vs Marks (Algebra 3).-One hundred and forty-four (144) of the 344 pupils who wrote the Algebra 3 examination (June 1932) were considered, these being the 144 for whom passing marks in Algebra 1 and Algebra 2 were available. The Pearson r representing the degree of relationship between the two paired series of scores is positive 0.28 ± 0.04. The two series of measurements may be summarized as follows: The range in IQ score values on the IQ testing (May 1932) was from 93 to 132 with a mean score of 115.54 and a standard deviation of 8.25; on the Algebra 3 Marks (June 1932) from 0 to 100 with a mean score of 61.66 and a standard deviation of 21.30.

Comparisons with Other Investigations

In order to find anything with which to compare the results of our investigation it was necessary to read reports of a large number of studies. It was found helpful to compare our results with the following excerpts, summaries, conclusions, etc., gleaned from other studies, more or less similar to our own:

Symonds[1] states that school success may be predicted by a general intelligence test such as may be administered in an ordinary school period to the degree represented by a coefficient of correlation of .48. Separate tests of elementary school subjects taken in combination are as satisfactory as a general intelligence test.

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1. Symonds, P.M., "Prediction of Success in High School," p.406.

Jordan[1] reports the following correlation with high school marks obtained by himself: Otis Group Intelligence Tests with High School Marks (composite) .450; with English .412; with Mathematics .281; with General Science .407; with History .340.

The correlations given by both Symonds and Jordan are for IQ vs Marks (Junior High School). All coefficients were less than .50, which means that as predictors of success in Junior High School achievement the intelligence test is practically useless. In general, the coefficient of correlation between IQ and Marks (Senior High School) is lower than the corresponding correlation for Junior High School.

Flemming[2] gives the correlation of marks in the Junior and Senior High School with Otis Self-Administering Test B as .52 and .32 respectively. In our experiment the average of r for IQ vs Marks (Senior High School) was 0.27 ± 0.04.

Jordan gives the value of r for IQ vs Marks in the following Junior High School subjects, as follows: with English .412; with Mathematics .281; with General Science .407; with History .340. In our study the values of r for IQ vs Marks in the following Senior High School subjects were: Lit. 4 + Comp. 4, av. r = .27; Alg. 3 + Geom. 3 + Trig. 1, av.r = .29; Hist. 4, r = .20; Phys. 2 + Chem. 2 + Biol. 1, av. r = .39. In general, our correlations are lower than those found between

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1. Jordan, A.M., "The Validation of Intelligence Tests.", J. Ed. Psych. 1923 (14) pp.348-366, pp. 414-428.

2. Flemming, C.W., "A Detailed Analysis of Achievement in the High School", p. 397.

IQ and Junior High School Marks. That is, our findings are in agreement with those of Flemming. It was impossible in our investigation to find a correlation between IQ and composite marks (Senior High School) because very few Grade XII pupils wrote exactly the same examinations in June 1932.

It was equally difficult to find any figures to compare with our correlations between Marks in a previous unit of Algebra and Marks in the final unit of Algebra. Miles, Kelley, Fretwell, and Ross[1] found correlations between elementary school marks and marks in the first year of high school as follows: .71, .789, .49 and .64 respectively. MacPhail[2] made a summary of the studies which have correlated high school marks and college marks. An average of twenty-eight such coefficients is .47. This correlation is small compared with the correlation of .64 between elementary school marks and high school marks found by Ross. These figures concern the prediction of success in the high-school or college course as a whole.

In the prediction of success in separate courses Gowen and Gooch have made elaborate correlation studies of the relation of high school marks to college marks in the University of Maine.[3] They found that the correlation between H.S. and college marks in Algebra was .407 and that H.S. marks in

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1. Symonds, P.M., "Measurement in Secondary Education," p. 399.
2. Ibid, pp. 313-314.
3. Ibid, pp. 429-430.

Algebra predict Elementary French (College) better than they do Algebra (College). Whitman[1] gives the average correlation between college Algebra and H. S. Algebra as .43. In our investigation we found for Algebra 1 vs Algebra 2, r = .47, for Algebra 2 vs Algebra 3, r = .46 and for Algebra 1 vs Algebra 3, r = .28 and for IQ vs Algebra 3, r = .28. The first two correlations are in quite close agreement with the correlations given above for H. S. Algebra vs College Algebra. We would expect the correlation between successive units of H. S. Algebra to be higher than between H.S. and College, because of the highly specialized nature of the latter. Our results are also in agreement with those of Brooks[2] who found that marks in a subject are best predicted by marks in the same subject during the previous year. Our results showed the correlation between a general intelligence test and marks obtained in Algebra 3 to be .28. This result also agrees with that of Brooks. In regard to the whole matter of prognosis of ability in separate subjects Symonds says, "It is very complex and the factors concerned are subtle and little understood, so that perhaps premature generalizations should not be attempted."[3]

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1. Symonds, P.M., "Measurement in Secondary Education," p.431.
2. Brooks, "Some Uses for Intelligence Tests," J. Ed. Res. 1922 (5), pp. 217-238.
3. Symonds, P.M., "Measurement in Secondary Education," p.436.

Besides the above comparisons which are more or less statistical, excerpts from three other more or less similar, non-statistical studies will be presented:

McCuen[1] attempted to determine the relative value of a number of test scores in predicting success in Algebra. The study was made in the Palo Alto Union High School and the success in Algebra was measured by the Douglass Stanford Diagnostic Algebra Tests. In all 116 students were given the tests. The author found that the Group IQ as determined by the Terman Group Test of Mental Ability is a better basis for grouping students in algebra according to probable success than any of the other criteria used in the study, which were the Revision of the Stanford Achievement Test and the sections on arithmetic computation and arithmetic reasoning of this test.

A study[2] reported by C. H. Toll has especial interest for us here. For five of Amherst's freshmen classes and for three classes followed throughout their entire college course scholastic grades were correlated with scores on at least one of the following tests: Army Alpha, Otis S-A, Terman Group, Smith College Information, Amherst Test and three tests constructed in 1924 by the American Council on Education. Toll found that none of the tests was especially valuable for predicting scholastic standing, the correlations

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1. McCuen, T.L., "Predicting Success in Algebra," J. Ed. Res. 1930 (21), pp. 72-74.
2. Toll, C.H., "Scholastic Aptitude Tests in Amherst College," Sch. & Soc. 1928 (28), pp. 524-528.

ranging from + .19 to + .38. The extremes of this range, interestingly enough, were found among the correlations for the Otis test, thus showing that the instrument varied in its predictive value from class to class.

Kaulfers[1] made a study of intelligence and Spanish failures. It was thought that the factors leading to failure in subjects other than Spanish would be about the same, accordingly, Kaulfers' conclusions are given here. He found that pupils of relatively mediocre intelligence may succeed if possessed of the proper habits of volition and application; pupils of mental ability below 105 IQ are at present bad risks in Spanish unless possessed of unusual interest in the subject and high capacity for effort and persistence. He concludes that the prediction of probable failure from the level of mental ability (as measured by the IQ) may hold in general for large numbers of students, but it is far too uncertain for purposes of individual prognosis and guidance. Other factors equally as important as mental ability condition failure in Spanish. An auxiliary basis, such as an index of industriousness or studiousness, must be used (collaterally) with measures of intelligence to insure even moderately trustworthy predictions of probable success.

McCuen's study would confirm our faith in the group intelligence test as an instrument for predicting probable

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1. Kaulfers, W.V., "A Comparative Study of the Intelligence of Beginners in College Foreign Language," Sch. & Soc. 1930 (31), pp. 749-750.

success in Algebra and other high-school subjects. Toll's study would tend to destroy our faith in the value of group tests, especially the Otis S-A, for this purpose. In our investigation it was impossible to find out whether the instrument varied in its predictive value from class to class. Kaulfers reminds us that in the prediction of probable success, intelligence is only one of the factors to be reckoned with. We must take into account such factors as interest in the subject, industriousness, persistence, etc.

Conclusion

These three studies suffice to illustrate the fact that there is neither general agreement as to the best means of predicting success in school or college nor as to the part intelligence, as measured by IQ scores, plays in determining this success.

CHAPTER IX

SUMMARY, CONCLUSIONS, AND CRITICISMS

Summary and Conclusions

This investigation was undertaken to determine the value of the record in intelligence tests as a means of predicting success in the later years of high school. The fact that in our study scores in intelligence tests and departmental examination marks in Grade XII do not show closer agreement may be explained in several ways. In the first place, the students dealt with are a selected group from which the less able individuals have been for the most part eliminated by failure to pass preceding units in the various subjects. All but 47 of the 754 students given the Otis Higher A examination have IQ's above 100 and most of the students have mental ages above seventeen. The level of intelligence in the case of practically every student is high enough to warrant adequate work in senior high school if interest, habit of work and the necessary preparation are also present. Factors other than intelligence play a large part in the student's success.

In the second place, very intelligent students have often not been trained to work to the limit of their capacity in the lower school. Their mental level has been high enough to enable them to do fairly satisfactory work with a minimum of effort. These students enter high

school with inadequate preparation and with the habit of working only enough to "get through." If this habit persists through all four years of high school it may lead to a very intelligent student's receiving poor marks.

In the third place, some of the most intelligent students are not interested primarily in high school work, and unless pride in academic success is sufficient to make these students put forth a determined effort to obtain high grades most of their energy may find its outlet in extra curriculum activities.

Lastly, the low correlations between IQ and achievement suggest that the validity of the test as a test which will differentiate between mental levels in pupils 17 or over may not be as great as could be desired. Our problem in the later years of high school is for the most part that of differentiating between abilities at the top of the scale, a far more difficult one than that of separating into groups the whole range of mental ability.

With an average prediction no higher than that obtained here it must be concluded that intelligence tests are neither a very truthful nor a very consistent basis for predicting average achievement for senior high school. The result of our tests showed (1) that marks correlated more highly with achievement than IQ scores did, (2) that the Intelligence Tests could not with fairness be used to exclude students who had passed the preceding units of the

subject, (3) that the IQ's selected the students whose work proved poorest, better than did marks on previous examinations.

The work of C.C. Ross and others has demonstrated that the entire grade school career of a pupil predicts high-school career far better and more consistently than any intelligence test, and at no expense other than a few minutes of work on the adding machine--a smaller amount of labor than is required to score a mental test. Several investigations have found secondary school marks the best basis of prediction for the first two years of university. Brooks has found the marks of the preceding year the best predictors of achievement in the later years of high school.

If these findings are correct, naturally we ask why intelligence tests are used at all to predict educational achievement. Before condemning intelligence tests it seems only fair to remember the criterion with reference to which they are judged practically useless as predictors of success. This criterion is invariably marks, usually final examination marks. This brings us back to the reliability of marks. In this connection, Huffaker[1] says, "If the criteria of scholastic success were as reliable as the present psychological tests it is probable that prediction would be satisfactory in three cases out of four."

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1. Huffaker, C.L., "Predictive Significance of the Correlation Coefficient," J. Ed. Res. 1930 (21), pp. 46-48.

The correlation between a test proposed as one having prognostic value and later demonstrated degrees of success or failure constitutes the final measure of whether the test is actually valid for the purpose claimed. Where success or failure is measured solely by academic marks, the prognostic value of intelligence tests is practically worthless. Group tests are chiefly useful for purposes of rough classification and for very rough prediction but either should be undertaken only after inquiry into various factors such as, Has the pupil taken tests before? Did the subject lose any time for any reason during the test? What has been the subject's training in school subjects? One of the greatest advantages of the intelligence test is that it enables the administration to adjust academic load to individual capacity so much more precisely than heretofore that many mediocre students, who would otherwise have dropped out of high school or college, are saved from failure, and thus are allowed to go on through college with as much speed and progress as their intelligence allows.

In conclusion, we would say that school marks should not be relied upon alone for prognosis but should be supplemented by intelligence tests. All the studies that have tried out both criteria find that they tell more together than either one does alone.

Criticisms and Suggestions

In chapter III of this essay the reliability of the measures used throughout the investigation was discussed in

some detail. The writer, however, feels that one or two suggestions from a paper by Gates[1] should be included here. This study presents data which show that at least under certain conditions, quite ridiculous IQ's may be derived from certain group tests. Gates gives an example of a fairly bright boy in Grade VII who earned a mental age of 46 years on one test giving an IQ of 408. Sir Francis Galton, whose IQ was estimated by Terman to be only about 200, would look pitiful beside this Myers prodigy. Gates urges a restraint of certain inappropriate uses of group tests. In conclusion Gates says, "We should not compute M.A.'s and IQ's from raw scores, but these raw scores themselves may be put to profitable use." The data presented by Gates should be sufficient to make one very cautious in the interpretation of group test scores and particularly cautious in the use of the M.A. or IQ. Gates says the factor of greatest importance is practice in group tests.

Symonds[2] points out three factors that make a test more reliable: "increased length; narrower range of difficulty of the items; more objective scoring." Anyone who has given group intelligence tests realizes the soundness of this observation. The imperative need is for longer tests, probably of two or three hours. There is a direct ratio between length of test and size of validity.

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1. Gates, Arthur I., "The Unreliability of M.A. and IQ based on Group Tests of General Mental Ability," J. App. Psych. 1923 (7), pp. 93-100.
2. Symonds, P.M., "Measurement in Secondary Education," Chap.XIV.

The Otis S-A Test of Mental Ability imposes a time limit. This means that there is the ever present group of individuals who will be penalized by this limit. Their M.A.'s and IQ's will be lower than they would be on a test where speed is not a factor.

Cattell[1] found that nine well-known intelligence tests tended to rate similarly children of average brightness, but gave widely divergent results for children whose IQ's fall at the extremes of the range. The Higher Otis S-A was especially criticized on this score.

The following paragraph from a study by George E. Tozer[2] gives us some idea of the factors influencing the thing we are trying to predict by a 30-minute group intelligence test:

"Many factors seem to enter into the school success of students. Sears mentions general mentality, special abilities, interests, physique, social and moral capacity, native language, home conditions, race traditions, home occupation, and social and economic status of the family. Proctor adds previous training, kind of teaching, health, character, vocational ambition and personal disposition. Viteles includes appearance, experience and temperament."

In conclusion, we would say that since the non-intellectual influences so greatly outnumber, and very probably outweigh, the intellectual factors leading to school success it is not surprising to find that our instrument, which is supposed to measure only native intelligence, is practically useless for prognostic purposes.

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1. Cattell, Psyche, "Comparability of IQ's Obtained from Different Tests at Different IQ Levels," Sch. & Soc. 1930 (31), pp. 437-442.
2. Tozer, George E., "A Statistical Prediction of High School Success for Purposes of Educational Guidance," J. Ed. Res. 1930 (22), pp. 399-402.

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